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CLASS D ELECTROACOUSTIC AMPLIFIER AND METHOD FOR COMPENSATION OF POWER SUPPLY VOLTAGE INFLUENCE ON OUTPUT AUDIO SIGNAL IN CLASS D ELECTROACOUSTIC AMPLIFIER

TECHNICAL FIELD

The invention relates to a class D electroacoustic amplifier, i.e. a class D audio amplifier, and a method for compensation of power supply voltage influence on an output audio signal in the class D electroacoustic amplifier.

BACKGROUND ART

One of the features of class D electroacoustic amplifiers is making use of a carrier signal apart from the audio signal. One of these amplifiers is the one known from the US patent No. 4,182,992, which consists of, among others, two transistors and a diode.

In turn, from the US patent No. 4,178,556 there is known a class D amplifying circuit that contains a modulating circuit to modulate an audio signal and a carrier signal.

There is also known, from the US patent No. 6,300,825 an amplifier that makes use of pulse width modulation of a signal, containing a comparator and an integrating circuit, which in order to increase the coefficient of rejection of supply voltage fluctuations, was supplemented with another integrating circuit.

From the Polish patent description P-325207 there is known a circuit for compensation of the constant component of the output voltage, powered by a stabilised voltage that generates a voltage compensation signal. This signal is added in an adder to a voltage signal of a triangular wave generator and in this way it changes the constant component of the output signal of the generator. The changed constant component influences the value of the duty cycle coefficient of the rectangular impulses generated at the output of the comparator, compensating to a degree the supply voltage fluctuations.

DISCLOSURE OF INVENTION

According to the present invention, in a class D electroacoustic amplifier, i.e. a class D audio amplifier, without feedback loop that contains a supply voltage source, an amplifier low-pass filter, a power stage controlled by a pulse width modulated signal, a saw-shaped voltage generator and a comparator, to one of which inputs an audio signal is sent, while its second input is connected to the adder of the compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, a low-pass filter and a high-pass filter are connected to the supply voltage source, and the reference voltage source is connected to an inverting circuit, whose input is connected to the low-pass filter output, while the high-pass filter output and the output of the inverting circuit are connected to a multiplier, whose output is connected to the input of another multiplier, whose second input is connected to the saw-shaped voltage generator, and the multiplier output is connected to one input of the adder, whose second input is connected to the saw-shaped voltage generator.

Preferably, the output signal $v_0(t)$ of the inverting circuit sent to the multiplier input, which is a modified constant of the supply voltage, is expressed by a formula $v_0(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$, where V_{DCref} is the voltage of the reference source, $v_i(t)$ is a slow-changing signal on the low-pass filter output, and the coefficient $k_1 \in <0.5; 2.0>$ and the coefficient $k_2 \in <0.2; 1.5>$.

Preferably, the output signal of the multiplier, which is the error signal $e(t)$, sent to the multiplier, is expressed by the formula $e(t) = k_3 \times v_0(t) \times v_{ii}(t)$, where $v_0(t)$ is a modified supply voltage constant, $v_{ii}(t)$ is a fast-changing signal on the high-pass filter output, and the coefficient $k_3 \in <0.8; 10.0>$.

Preferably, the output signal $V_{CM}(t)$ of the adder, which is the corrected carrier wave signal, sent to one input of the comparator, is expressed by the formula $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$, where $V_C(t)$ is a high frequency carrier wave generated by the generator, $e(t)$ is the error signal, and the coefficient $k_4 \in <0.2; 1.5>$ and the coefficient $k_5 \in <0.2; 3.0>$.

The object of the invention is also a method of compensation of supply voltage influence on the output audio signal in an electroacoustic amplifier,

which contains a saw-shaped signal generator and a comparator making use of pulse width modulation, and which is powered from a power supply, and to whose input an audio signal is sent, and whose second input is connected to an adder of a compensation circuit of supply voltage influence on the output audio signal, to which a voltage from a reference voltage source is sent, from the power supply source a fast-changing signal $v_{ii}(t)$ is extracted and a slow-changing signal $v_i(t)$, which is inverted and multiplied by the a value of a reference supply voltage V_{DCref}, which results in an output signal $v_o(t)$, which then is multiplied by a fast-changing signal $v_{ii}(t)$, which results in an error signal $e(t)$, which then is multiplied by a saw-shaped signal $V_C(t)$ from the generator, and the resulting signal is added to a saw-shaped signal $V_C(t)$ and as a corrected carrier wave $V_{CM}(t)$ is sent to one of the inputs of the comparator, which makes use of pulse width modulation, and to its second input the audio signal is sent.

BRIEF DESCRIPTION OF DRAWINGS

The object of this invention is shown in implementation examples on the enclosed drawings, where fig. 1 shows a block diagram of a class D electroacoustic amplifier with a system for compensation of influence of supply voltage fluctuations, figs. 2 and 3 show the result of computer simulation with the compensation system present and the supply voltage of 27 V, figs. 4 and 5 show the result of computer simulation without the compensation system present and with the supply voltage of 27 V, figs. 6 and 7 show the result of computer simulation with the compensation system present and with the supply voltage of 40 V, figs. 8 and 9 show the result of computer simulation without the compensation system present and with the supply voltage of 40 V.

BEST MODE FOR CARRYING OUT THE INVENTION

The solution of the compensation system that is presented above can be applied in any desired system that contains a discrete class D audio line, and in the description it is supplemented with an electroacoustic amplifier. A class D electroacoustic amplifier 1, i.e. a class D audio amplifier, without feedback loop,

shown in fig. 1, contains a comparator 3, to whose input an audio signal is sent, and a generator 4, a power stage 2, using pulse width modulation, a supply voltage source 8, an amplifier low-pass filter 14, and a loudspeaker device being the load of the amplifier 1. In the shown amplifier 1, an audio input signal 21 and an output audio signal 28 are not included in the feedback loop and coefficient of supply voltage fluctuation influence rejection is 0 dB. So to reduce the supply voltage influence on output audio signal, the electroacoustic amplifier 1 has been supplemented with a compensation system containing a low-pass filter 9 and a high-pass filter 10, both of which are connected to a power supply voltage source 8.

The reference voltage source 12 of the compensation system is connected to an inverting circuit 11, whose input is connected to the low-pass filter 9 output. The high-pass filter 10 output and the inverting circuit 11 output are connected to a multiplier 7, whose output is connected to a multiplier 5 input, whose second input is connected to a saw-shaped or triangular-shaped voltage generator 4, while the multiplier output is connected to one of the adder 6 inputs, whose second input is connected to a saw-shaped or triangular-shaped voltage generator 4.

In the presented electroacoustic amplifier 1, with the compensation circuit of supply voltage influence on an audio output signal, the input signal 21 is sent to the '-' input of the comparator 3, where the comparison of the audio signal 21 with the carrier signal 26 $V_C(t)$, which is a carrier wave of high frequency in the range of 40 kHz to 1 MHz, takes place.

In this system, the voltage from the power supply source 8 is sent to the low-pass filter 9 and the high-pass filter 10. From the high-pass filter 10 output, a fast-changing signal 23 $v_{ii}(t)$, which is the separated variable component of the supply voltage, is sent to one of the multiplier 7 inputs, while the slow-changing signal $v_i(t)$, which is the separated constant component of the supply voltage, from the low-pass filter 9 is sent to the inverting circuit 11 input. Moreover, the voltage V_{DCref} of the reference voltage source 12 is connected to the inverting circuit 11. Then, the signal 24, given by the formula $v_0(t) = k_1 \times V_{DCref} / [k_2 \times v_i(t)]$, from the inverting circuit 11 output is sent to the multiplier 7

input, where the multiplying of this signal with the fast-changing signal 23 from the high-pass filter 10 output takes place, and the received error signal, expressed by the formula $e(t) = k_3 \times v_0(t) \times v_{fi}(t)$, from the multiplier 7 input is sent to one of the multiplier 5 inputs. In the multiplier 5, the multiplying of the carrier signal 26 $V_C(t)$ from a saw-shaped or triangular-shaped voltage generator and the modified constant component 25 $e(t)$ from multiplier 7, is performed. Then, the signal from the multiplier 5 is added in the adder 6 to the carrier signal 26. The received signal 27, which is the corrected high-frequency carrier wave, expressed by the formula $V_{CM}(t) = k_4 \times V_C(t) \times [1/k_5 + e(t)]$, from the adder 6 output is sent to the '+' input of the comparator. With the use of the multiplier 5, the adder 6, the multiplier 7, the filter 9, the filter 10, the inverting circuit 11 and the reference voltage source 12, a corrected carrier wave $V_{CM}(t)$ is generated, by which it is possible to maintain a constant envelope of the audio output signal sent to the loudspeaker device 13. The coefficients in the formulas take the values from the ranges $k_1 \in <0,5;\ 2,0>$, $k_2 \in <0,2;\ 1,5>$, $k_3 \in <0,8;\ 10,0>$, $k_4 \in <0,2;\ 1,5>$, $k_5 \in <0,2;\ 3,0>$ and $k_6 \in <0,2;\ 3,0>$.

The presented system solves the problem of a low coefficient of rejection of influence of supply voltage fluctuations, called the Power Supply Rejection Ratio coefficient (PSRR), when the amplifier has no feedback loop. In this system, in order to increase the Power Supply Rejection Ratio coefficient, signals distorting the source voltage 8 signal are generated without the use of the audio signal. Thus, the audio signal is not modified directly, but indirectly through a modification of a carrier signal. In the presented system, the compensation of the constant component fluctuations takes place through the multiplier 5, the adder 6, the low-pass filter 9, the inverting circuit 11, and the compensation of the variable component fluctuations takes place through the multiplier 5, the adder 6, the high-pass filter 10, the inverting circuit 11 and the reference voltage source 12.

Further figures show the results of a computer simulation of the amplifier. Fig. 2 shows a signal 31 at the output of the power stage with the power supply influence compensation system present. The signal 31 is amplitude-modulated with a variable component of a 3 V amplitude and a

frequency 33 of 1 kHz, while the frequency 32 of the audio signal is 5 kHz and the supply voltage is 27 V. Fig. 3 shows a sinusoidal signal with a frequency 34 of 5 kHz at the output with a load of 8 Ω..

In turn, fig. 4 shows a signal 37 at the output of the power stage without the power supply influence compensation system present. This signal is also amplitude-modulated by a variable component of a 3 V amplitude and a frequency 36 of 1 kHz, while the frequency 35 of the audio signal is 5 kHz. Fig. 5 shows a sinusoidal signal with a frequency 38 of 5 kHz at the output with a load of 8 Ω. The envelope of the output wave is visibly modulated and the frequency 39 of amplitude fluctuations is 1 kHz.

Fig. 6 shows a signal 41 at the output of the power stage with the power supply influence compensation system present and with values of voltages changed in comparison with signal 31 in fig. 2. The signal 41 is also amplitude-modulated by a variable component of a 7 V amplitude and a frequency 43 of 1 kHz, while the frequency 42 of the audio signal is 5 kHz and the power supply voltage is 40 V. Fig. 7 shows a sinusoidal signal with a frequency 44 of 5 kHz at the output with a load of 8Ω, as well.

Fig. 8 shows a signal 45 at the output of the power stage without the power supply influence compensation system present. The signal, similarly to the one shown above (fig. 5), is amplitude-modulated by a variable component of a 7 V amplitude and a frequency 46 of 1 kHz, while the frequency 45 of the audio signal is 5 kHz. Fig. 9 shows a sinusoidal signal with a frequency 48 of 5 kHz at the output with a load of 8 Ω. The envelope of the output wave is visibly modulated and the frequency 49 of amplitude fluctuations is 1 kHz.

The compensation system of power supply influence on output audio signal for the class D electroacoustic amplifier, presented above, solves to a significant degree problems of stability of the amplifier, including problems of setting a phase margin.